3. Energy

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INTRODUCTION

Energy is one of the fundamentals on which modern society, not just in Europe, but in the whole world, rests. Without efficient energy industries it would be impossible to achieve the current state of national and international communication, mobility, trade and economic growth. Consequently the energy sector is seen as particularly important for economic development.

The energy industry is part of the primary sector of the economy. The demand for energy is derived from the demand for other products. Energy is used in the production of heat, light, motion and communication which in turn enables energy users to cook meals, heat houses, drive automobiles, utilise electrical tools and machinery in industrial production, use electronic means of communication and so on. The main factors which influence the global demand for energy are the climate, the level of economic activity, per capita income and the size of the population. Colder weather, economic growth, rising real incomes and population growth consequently lead to an increase in the demand for energy.

Energy used by industry and private households is partly derived directly from primary sources like oil, natural gas and coal and partly from electricity generated from primary sources like fossil fuels (coal, oil and natural gas), nuclear energy and renewable energy (for example hydro and wind power, biomass or geothermal energy). For statistical purposes, energy resources which are directly used by private households, industry or for transport purposes (final energy consumers) are classified as secondary energy, whereas those which need to be refined or transformed in order to become secondary energy are known as primary energy.

The majority of the world's demand for primary energy is met by fossil fuels. Even in highly developed countries, like those in the EU, energy derived from nuclear power and renewable resources accounts for little more than 20 per cent of total energy consumption (European Commission 1999a). Oil is the largest source of primary energy in the EU, meeting about 46 per cent of energy demand (European Commission 2000a, p.41).

However, nuclear energy is now the main *domestic* source of supply in the EU, followed by natural gas.

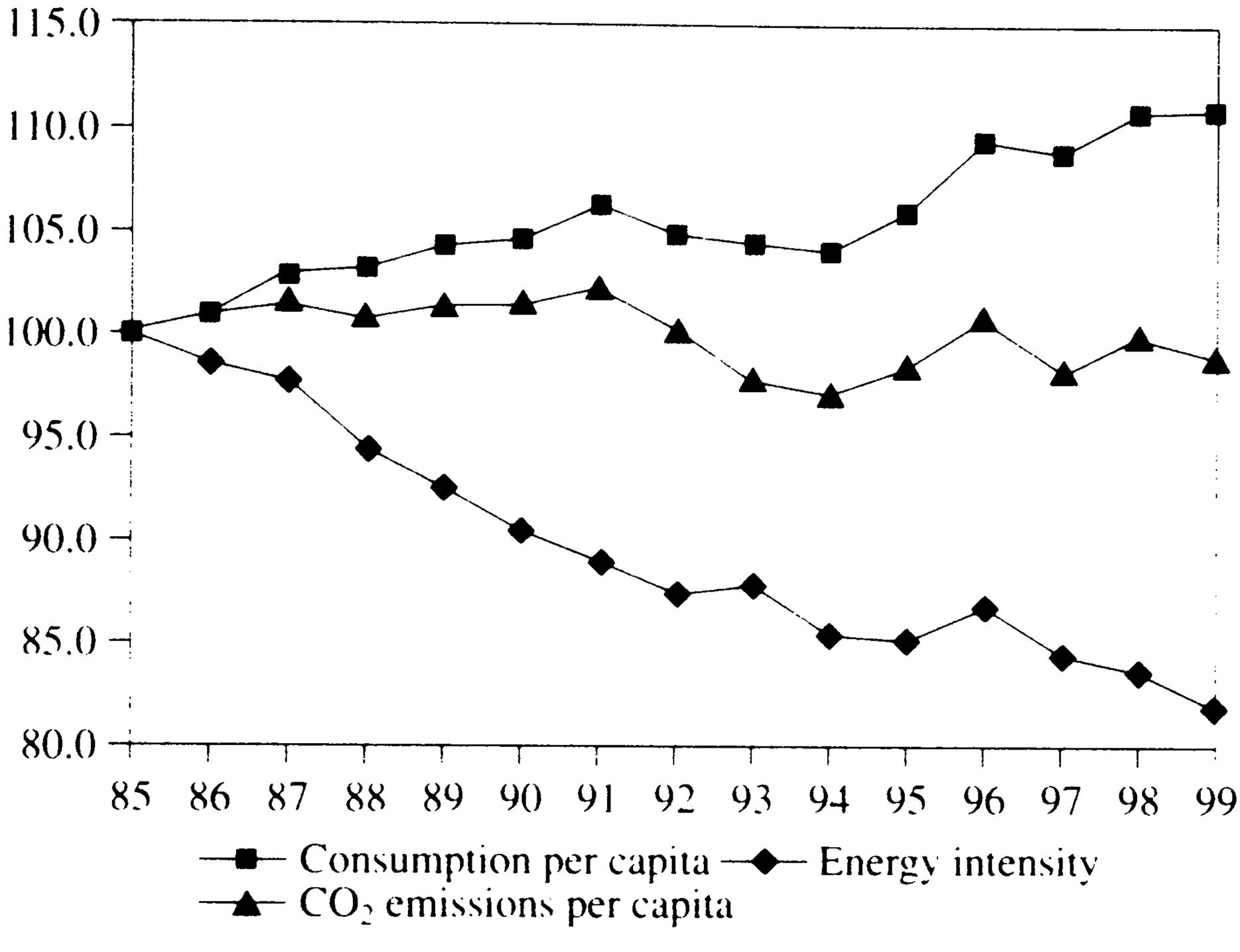
The depletion of existing stocks of fossil fuels within the EU, the development of new technologies, changes in lifestyle and public opinion, energy taxes, environmental regulations and the promotion of competition in energy markets all have a significant impact on the development of the EU energy supply. Together with price fluctuations in international energy markets, these factors have led to changes in the relative costs of both the generation and the use of different sources of energy. Since the 1980s this has resulted in a continuous process of substitution of different energy sources as well as of research and investment in new technologies to increase energy efficiency.

A STATISTICAL OVERVIEW

In 1998, the EU energy industries employed about 1.5m people, and accounted for around 3.8 per cent of EU GDP. Increasing productivity has meant substantial employment losses in recent years: for example between 1995 and 1998, employment fell by 9.7 per cent (European Commission 2000d, p. 52).

Figure 3.1 charts three key trends since 1985 in index form. It is clear that consumption per head has shown a strong upward trend over the period. In 1999, the consumption index stood nearly 11 per cent higher than it did in 1985. The trend in energy intensity - the ratio of energy consumption to GDP – has shown a strong downward trend, reflecting the fact that although energy consumption per head has risen, efficiency in the use of energy has substantially increased. The figure also shows what has been happening to CO_2 emissions per head, a key indicator of pollution levels from energy. The trend in these emissions is slightly downward.

In Table 3.1 the consumption of energy in individual EU member countries is shown. Not surprisingly, Germany, France and the UK account for well over 50 per cent of total EU consumption. Countries vary substantially in the mix of energy sources that they use. For example, the percentage attributable to solid fuels varies from 2.9 per cent (Luxembourg) to 31.7 per cent (Spain). Again, the percentage of natural gas ranges from 1.4 (Sweden) to 46.5 (Netherlands). Nuclear energy also shows considerable variation with some countries receiving no energy from this source. The last column in Table 3.1 indicates substantial differences in import dependency, measured as net imports as a percentage of stocks and gross inland consumption. Both Denmark and the UK are net exporters, of both natural gas and oil.



Source: Derived from figures from EU Energy and Transport in Figures 2001 (European Commission 2001f). Consumption is gross inland consumption.

Figure 3.1 EU energy trends: 1985–99

ENERGY SUPPLYING SECTORS IN THE EU

From a supply-side perspective, the energy industry can be divided into three main elements: the mining and exploitation of primary energy, the generation of secondary energy and the distribution of secondary energy to end consumers.

The energy sector is to a large extent operating in a global context. Consequently worldwide changes in the supply of and demand for energy affect European energy markets. The continuing increase in the world's population and average real per capita income will ensure that the global demand for energy maintains its expansion. Rising demand for commercially produced energy, particularly in developing and newly industrialised countries, will lead to an increase in energy prices unless energy production is expanded and/or the use and generation of energy becomes more resource efficient.

Table 3.1 Consumption and import dependency of energy in EU countries, 1999

Country	Gross inland consumption[1] (% of EU total in brackets)	of which[2] Solid fuel (%)	Oil (%)	Nat. gas (%)	Nuclear (%)	Renewables (%)	Import dependency[3] (%)
Belgium	56.8 (3.9)	13.0	39.6	23.4	22.2	1.2	76.5
Denmark	20.4 (1.4)	22.5	47.1	21.6		9.3	−13.6
Germany	339.4 (23.5)	23.7	39.2	21.2	12.9	2.6	59.2
Spain	26.8 (1.9)	31.7	58.2	4.5		5.6	66.1
Greece	117.5 (8.1)	17.1	52.9	11.3	12.9	5.2	76.6
France	249.9 (17.3)	6.1	36.0	13.8	39.3	7.0	51.9
Ireland	13.9 (1.0)	18.0	58.3	21.6	-	2.2	83.1
Italy	175.2 (12.1)	6.7	51.7	31.8		7.8	80.9
Luxembourg	3.4 (0.2)	2.9	61.8	20.6	-	-	97.3
Netherlands	74.4 (5.1)	10.1	37.6	46.5	1.3	2.0	29.7
Austria	28.4 (2.0)	10.6	42.3	23.9	-	23.2	66.1
Portugal	24.0 (1.7)	15.8	65.0	7.9		11.3	89.9
Finland	32.7 (2.3)	16.2	30.3	10.1	18.0	22.3	51.7
Sweden	50.4 (3.5)	4.8	31.0	1.4	37.5	26.8	35.1
UK	229.2 (15.9)	16.1	35.2	36.2	10.8	1.1	−20.3
EU	1442.4 (100.0)	14.5	41.3	22.8	15.3	5.9	47.1

Notes:
1. Measured in terms of million of tonnes of oil equivalent.
2. The row percentages may not sum to 100 because of rounding and estimation errors.
3. Measured as net imports/(bunkers + gross inland consumption).

Source: Derived from figures from EU Energy and Transport in Figures 2001 (European Commission 2001f).

Solid Fuel

In the EU solid fuels are mainly used for electric or steam power generation (European Commission 1999b, p.46). The contraction of the European iron and steel sector and the switch by private households from coal to gas, oil or electricity has eroded substantial parts of the market for solid fuels during the last twenty years. The liberalisation of the power generating sector in the 1980s and 1990s led to a substitution of solid fuels like coal by natural gas. Not only is the cost of generating power from gas cheaper than that from coal, but also environmental standards which restrict the amount of permissible CO_2 pollution can be more easily met with gas, thus giving it a further cost advantage.

Due to relatively high mining costs and low quality, coal mined in the European Union is not internationally competitive. EU producers of coal outside the UK have received subsidies during the 1990s which frequently exceeded the cost of coal imported from non-EU countries. In 2000, however, the EU began to phase out subsidies to the coal industry. At the same time tariff measures that protected EU coal producers from international competition were relaxed. As a result EU coal production is expected to continue to drop over the medium term.

Rising gas prices after 2010, the decommissioning of nuclear power plants after 2015 and technological developments which increase the energy efficiency of power generation from coal are likely to lead to a renewed increase in the demand for solid fuels by the power generating industry after 2010. This increase in demand will primarily benefit the cheaper and more energy intensive solid fuels mined outside the EU and is at best expected merely to slow down the decline of the EU solid fuel industry (European Commission 1999b, p.47).

While many countries still tightly regulate their domestic energy markets in order to protect domestic production and safeguard supply, the international market for solid fuel is highly competitive. EU businesses importing solid fuel from outside the EU can choose from a wide range of possible supplier countries and firms. As solid fuels are mostly transported by ship or rail, the need for suppliers and consumers to invest in large scale distribution infrastructure networks is rather limited.[1] This enables both exporting and importing countries' flexibility in choosing trading partners.

Natural Gas

The growth in the demand for gas over the past ten years has been caused both by a slow but continuous expansion of the demand for gas by final consumers and a more rapid increase in the demand for gas as a primary

energy resource by the power generation sector (European Commission 1999b, p.49). The high energy efficiency of gas in power generation, comparatively low levels of pollution associated with gas and price reductions due to increasing competition in European and domestic gas markets, have increased its competitiveness compared with other sources of primary and secondary energy.

The UK and the Netherlands are by far the largest producers of gas in the EU, followed by Germany, Italy and Denmark. Approximately half of the gas consumed in the EU is imported from outside the EU. Russia, Norway and Algeria are the largest sources of these imports.

The increasing international demand for gas is expected to outgrow the increase in supply in the near future. Consequently relative gas prices are expected to rise by 2010 (European Commission 1999b, p.49). This is expected to lead to a partial substitution of gas as a primary source for power generation by solid fuels, thereby reversing the current trend.

The majority of gas is distributed via pipelines. The gas supply of the EU depends on long-distance pipelines for gas imports and a network of pipelines within the EU which connect the end users to the supply.[2] Due to the high sunk costs associated with the development of a pipeline network and the low marginal costs of connecting additional users, gas distribution networks are often regarded as a natural monopoly. Consequently attempts to liberalise the European gas market have concentrated on generating competition among firms which exploit gas or distribute it to end consumers. Market entry for gas exploiting companies or distributors is virtually impossible unless they have access to the existing pipeline networks. For the successful liberalisation of the European gas market equitable access to the gas transmission infrastructure for all competitors is crucial.

There are considerable differences in the structures of the domestic gas markets in individual member countries within the EU. These structures range from publicly-owned vertically-integrated monopoly companies to competitive gas exploitation and distribution markets supplied by non-integrated private companies and protected by a tight supervision of the monopolies which run the pipeline network. The splitting up of vertically-integrated gas companies in the UK (DTI 2000, p.12), for instance, is seen as preventing discrimination against those competitors in the production or distribution sector who are not organisationally linked to the pipeline network.

In order to take account of the differences in the market structures of the member countries the EU gas directive (98/30), which aims to liberalise gas markets both nationally and within the EU, does not require the breaking up of gas companies. It merely stipulates that vertically integrated gas companies which own the gas network must keep separate accounts for the different parts of their business. This requirement aims to increase trans-

parency over the true costs of gas transmission, which in turn form the basis for access price negotiations. The owners of these networks are also required to provide access for independent domestic or EU-member companies as long as it is economically feasible to do so. With regard to the transmission fee, the EU offers two options: the fees for the use of the network are either negotiated between the individual supplier and customer or they can be set out as fixed tariffs which apply to all potential customers. The EU gas directive further requires member countries to identify large scale gas users, particularly electricity generators, who are permitted to negotiate the supply of gas directly with foreign or independent domestic suppliers. As the degree of liberalisation increases, more and more consumers will be allowed to choose their gas supplier (European Commission 2001b; Percebois 1999, 10).[3]

These measures are expected to increase the level of competition in the European gas market significantly by 2008 and to lead to falling energy prices (European Commission 2000b).

Because of the small number of countries importing gas into the EU, the possibility exists that the largest Russian gas company, Gazprom, might seek to develop a dominating market presence in Europe through an initial low price strategy (European Commission 1999b, p.92). In order to reduce the risk of exploitation by a dominant supplier, the EU is actively encouraging a diversification of suppliers by subsidising the construction of long-distance gas pipelines to a number of other potential gas supplying countries, particularly in North Africa (European Commission 1997).

The liberalisation of EU gas markets is expected to lead to an increase in the intensity of competition not only among gas distributors but also among businesses at all stages of the gas value chain. Currently, however, both the market for gas production for the EU market and the market for gas distribution within the EU are dominated by a small number of firms. Gazprom, Esso, Sonatarch and Shell currently produce more than half of the EU gas supply. The eight largest companies in the market are responsible for more than 75 per cent of production (European Commission 2001e, p.76). Similarly the seven largest gas distribution companies Gasunie, SNAM, Ruhrgas, GdF/CFM/GSO, Centrica, Gas Natural and Distrigaz account for more than 75 per cent of the demand for gas in the EU (European Commission 2001e, p.82). The high concentration of market power on the demand side of the market for gas in the EU can on the one hand be seen as necessary in order to ensure a balance of power in the market. On the other hand this concentration exposes the customers of the gas distribution companies to the threat of price exploitation by their suppliers if there is no EU-wide or national regulation of gas prices or profit margins of gas distribution companies.

Oil

Like gas, the majority of oil production in the EU takes place in the North Sea. The UK is by far the largest producer of oil in the EU. Denmark is a distant second while oil production in Italy, France, Germany and the Netherlands is only marginal. Between two-thirds and four-fifths of the EU's oil supplies are met by imports from outside the EU.

The growth in the demand for oil is fuelled mainly by the increasing demand for oil as a secondary energy resource from the transport sector. The demand for oil as a primary energy resource is roughly in line with the growth of the primary energy sector as a whole, so that oil is expected to retain its market share in this sector in the next 15 to 20 years.

The demand side of the oil market is characterised by a large number of potential customers who seek oil for a variety of uses, ranging from transport and heating to the production of plastics and fertiliser.

On the supply side, the international oil market is characterised by oligopoly in two areas. In oil export production, a comparatively small number of countries, most of them situated in the Middle East, dominate the market. Oil exploitation in the main oil exporting countries is either organised through nationalised monopoly companies or through licensed multinational companies (see Kemp 1995). The state therefore usually retains the decision about the volume of exploitation.

In order to maximise their market power, the majority of large oil exporting countries formed the Organisation of Petroleum Exporting Countries (OPEC) cartel in 1960 to regulate the quantities of oil produced and sold on the international market.[4] The price elasticity of demand for oil is rather low, particularly in the short term, as energy substitution usually requires significant investments. In the past the cartel has managed several times to take advantage of the low price elasticity and to raise revenues from oil exports by organising a reduction of the oil supply, most notably during the oil crises in 1973/74 and 1979. When price elasticities are sufficiently low, the reduction in quantities will be more than compensated by the increase in prices.[5] However, in cartels which regulate the volume of trade, free-rider positions are particularly profitable. Non-member countries and individual member countries that break the rules are able to benefit from increased prices while expanding their production. As more and more member countries try to benefit from the free-rider position and exceed the agreed levels of production, the supply of oil increases and oil prices begin to fall. For this reason it is difficult for OPEC to reach credible agreements among all member countries to reduce output.

In order to reduce their vulnerability to the market power of OPEC, EU member countries have subsidised the diversification of energy sources,

most notably increasing the use of gas and nuclear power, and have set incentives for a more energy efficient use of oil. The latter has in part been achieved by increasing taxes on petrol and diesel, thereby making vehicles with lower fuel consumption more attractive to consumers.

Oligopoly also exists on the supply side of the European oil market which is dominated by large, vertically integrated, multinational oil companies that dominate distribution systems and refineries. During the 1980s and 1990s the concentration process in the oil industry accelerated significantly. Takeovers and mergers allow participating companies to benefit from economies of scale and scope, increasing the utilisation and thereby the efficiency of distribution networks and refineries.

In the 1980s multinational oil companies started to adopt just-in-time delivery in order to reduce capital costs. This has left them more financially vulnerable to the volatility of oil prices (*Economist* 2000). This in turn has provided another incentive for mergers among multinational oil companies, as larger companies benefit from their improved access to capital markets, which enables them to take bigger financial risks than small companies.

The drawback of this development is, however, that consumers are more likely to be exposed to exploitation through collusive action as market concentration increases. While the regulatory authorities have so far not been able to demonstrate that oil companies have formed illegal cartels, most European countries regularly instigate enquiries based on a suspicion of collusive behaviour among oil companies with regard to both transport and heating fuel pricing.

Renewable Energy

Renewable energy accounts for about 10 per cent of the production of primary energy in the EU and roughly 5 per cent of the consumption of primary energy. The production of renewable energy, which comprises hydro energy, wind and solar energy as well as geothermal heat, biomass energy generation, biofuels and hydrogen, varies significantly across different EU member countries. This is due not only to different environmental policies but also to the geographical characteristics of the individual countries. In Sweden, Austria and Finland, for example, one-fifth of total energy consumption is provided by renewable energies, while in many other member countries the use of renewable energy is negligible. The proportion of renewable energy in the EU's production of primary energy is expected to double by 2020, although this will be mainly due to the anticipated fall in the primary production of fossil fuels (European Commission 1999b, p. 52).

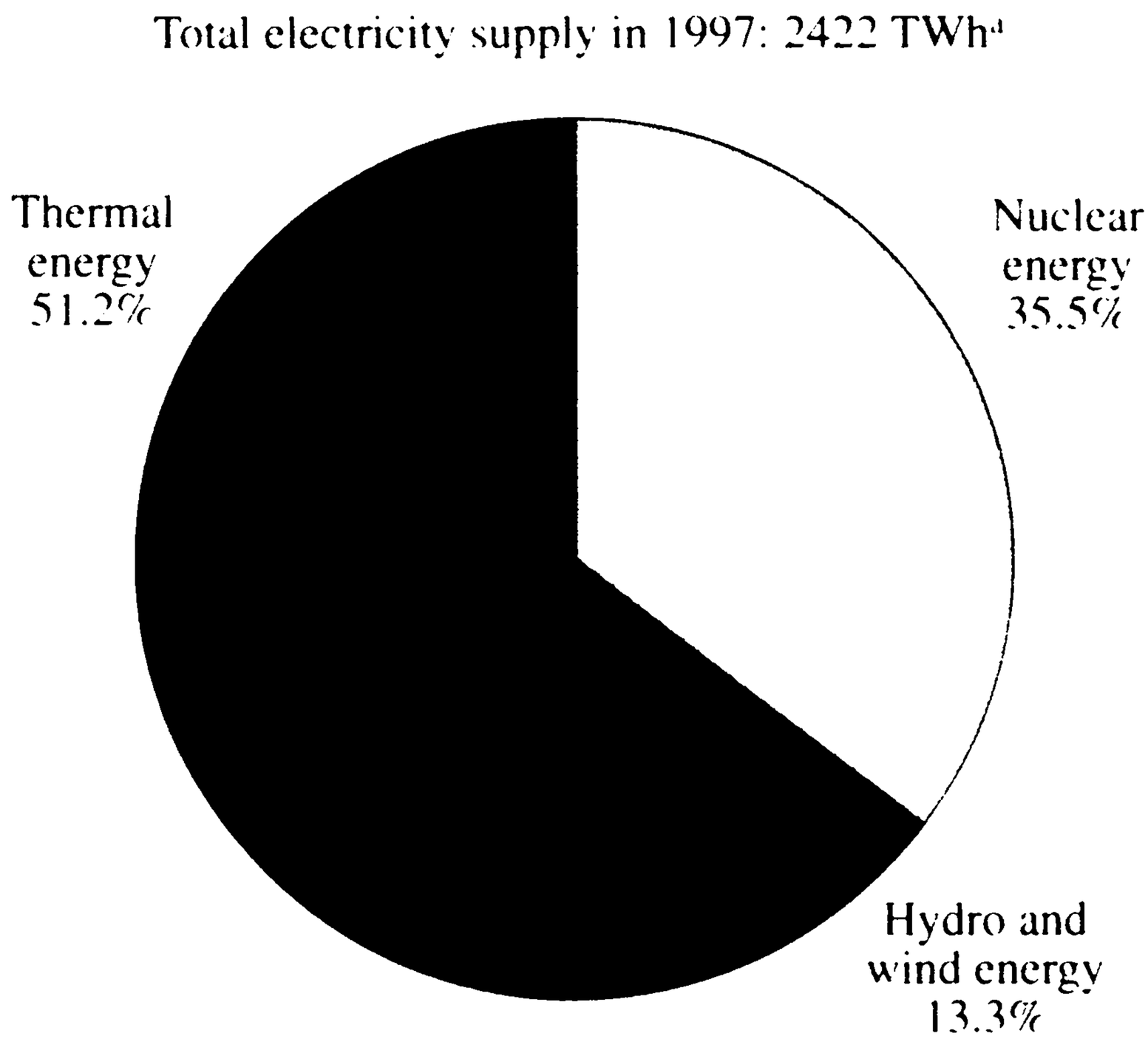
Electricity

Most sectors of developed economies show a long-term trend towards electrification. The fact that electricity is easy to control and measure and clean at the point of use makes it attractive for use in the industrial, service and domestic sectors alike. In the EU the long-term elasticity of electricity demand with regard to GDP during the 1990s was close to unity (European Commission 1999a, p. 31). Electricity continues to increase its market share.

Electricity generation

The three main sources for electricity generation are thermal energy, nuclear energy and hydro and wind energy. As Figure 3.2. shows, supply is still dominated by thermal energy, that is energy derived mainly from burning gas, coal or oil.

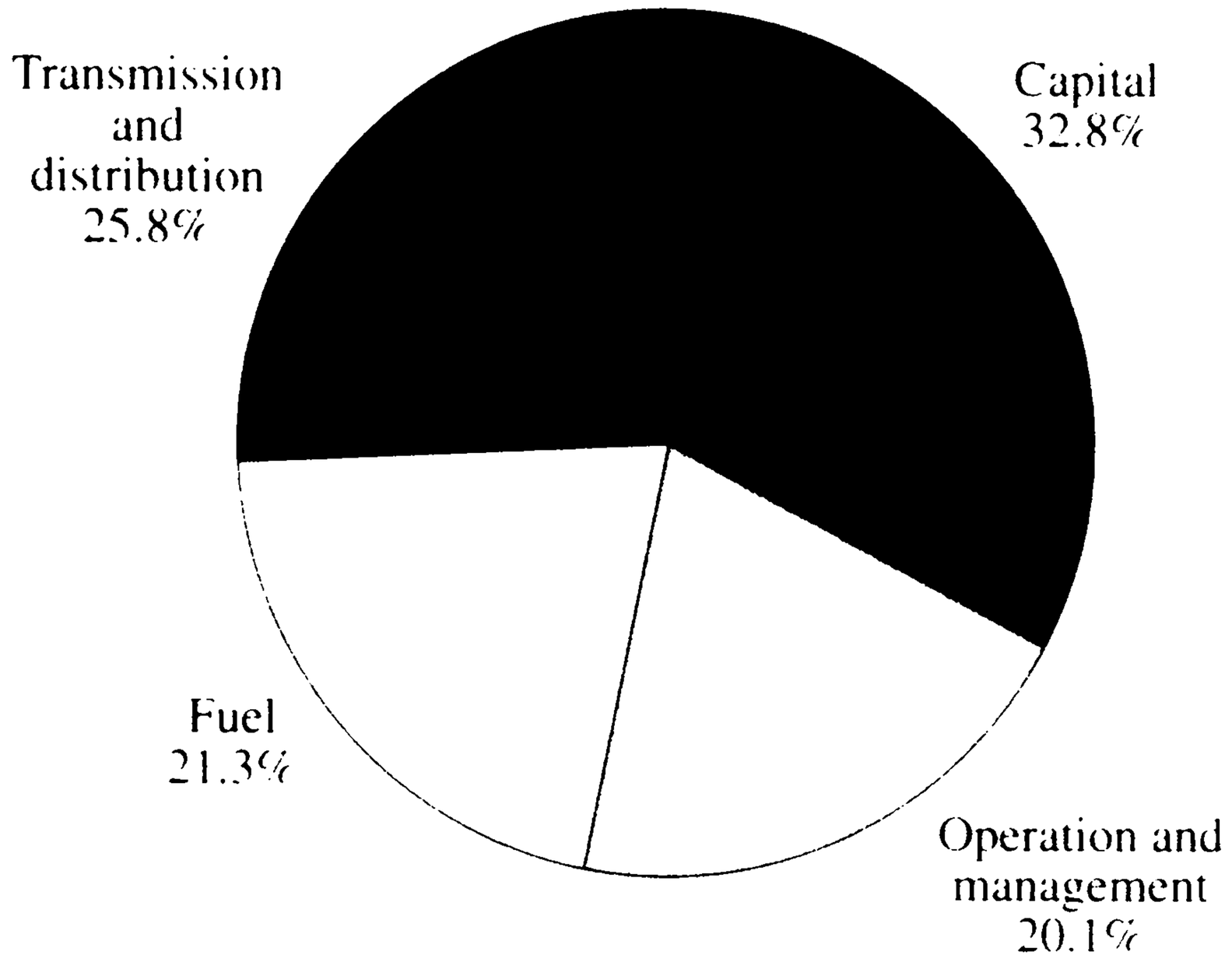
Investments in large-scale power generators require considerable and highly specific long-term capital investment which leads to comparatively high capital costs. In 2000 these costs accounted for 33 per cent of total costs (see Figure 3.3).



Note: [a] TWh = Terawatt-Hours (10^{12} Watt-hours).

Source: European Commission (1999a, p. 31).

Figure 3.2 Supply of electricity in the EU by energy source in 1997



Note [a] At constant 1990 prices.

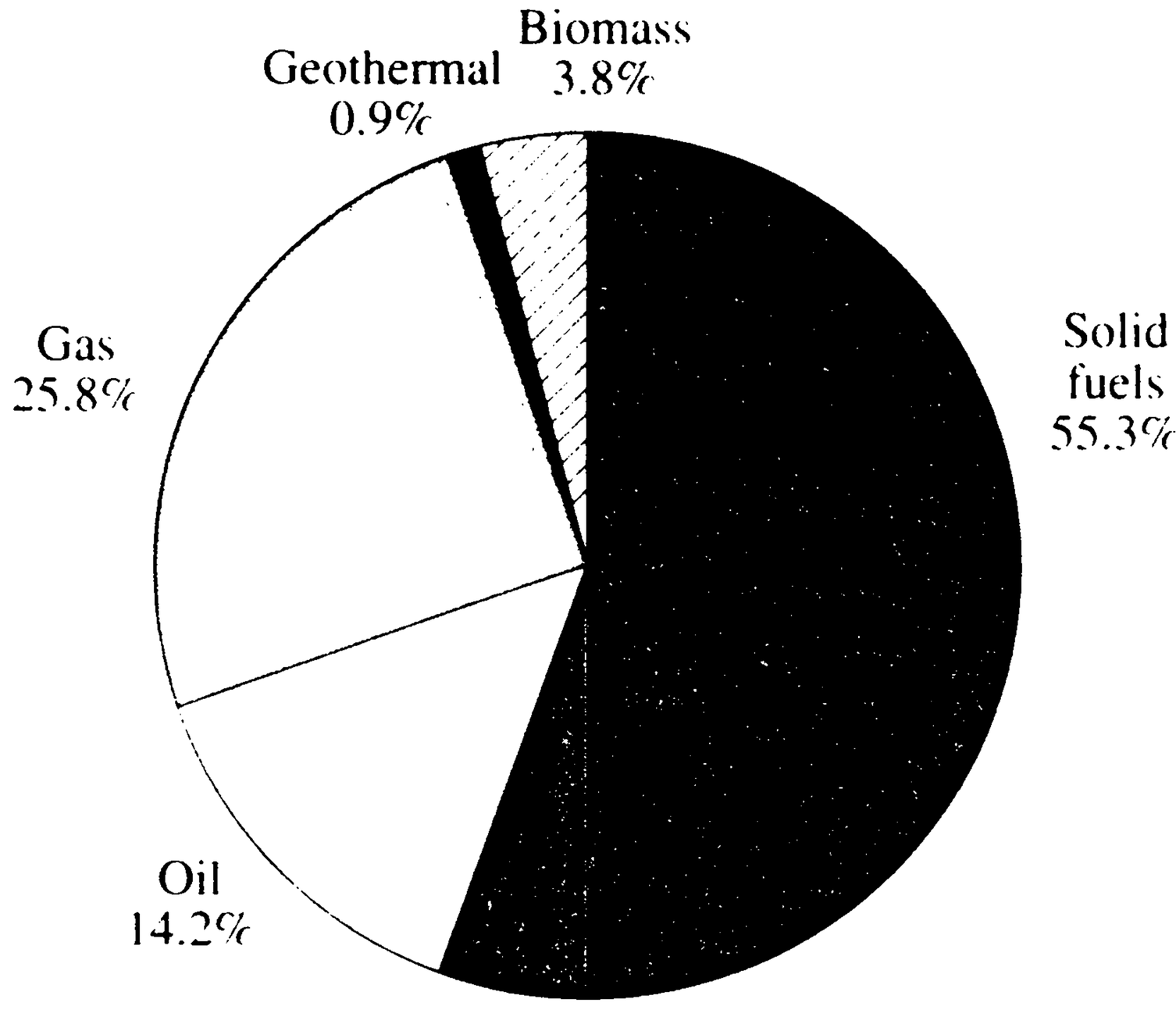
Source European Commission (1999b, p.62).

Figure 3.3 Electricity generation cost structure in the EU in 2000

While most generators have a life expectancy of about 40 years, the investment is highly specific and cannot be recovered if the production switches to alternative primary energy sources. This is one reason why electricity generators are slow to react to price changes on international markets for primary energy or environmental regulations through factor substitution (see Deutsche Bank Research 1999).

While the proportion of gas used in electricity production increased rapidly during the 1980s and 1990s, mostly at the expense of coal, the use of oil fluctuated around a market share of 15 per cent (see Figure 3.4). This pattern reflects price factors in the markets for both primary resources and electricity generation plants. As it is cheaper to provide electricity generating capacity by investing in gas turbines than by investing in coal, nuclear or hydroelectric capacity, gas fuelled electric power plants have become increasingly popular. As the variable costs of gas are higher than those of coal or water, gas powered electricity generators are often used to supply peak capacity as these are less costly to run below capacity than those for water, coal or nuclear energy.

Nuclear energy, which has been seen as one possible solution to the



Note [a] Million toe. toe = tonne of oil equivalent or 10^7 kilocalories or 41.86GJ.

Source European Commission (1999a, p. 32).

Figure 3.4 Fuel inputs for thermal power generation in the EU

energy import dependency of many countries, still provides a considerable amount of electricity, particularly in countries like Germany and France. Compared with other methods of energy generation, it is rather expensive as it requires huge capital investments and an indeterminate commitment to the long-term storage of nuclear waste and decommissioned energy generators. In Germany financial considerations and concern about the risks of radioactive pollution led to a political agreement in 1999 between the energy industry and the Schröder government about a long-term exit from nuclear power. Other countries, like Sweden, are determined to use their nuclear energy capacity until it comes to the end of its technical life expectancy. This strategy enables power generators to postpone investments in replacement capacity and helps to reduce CO_2 emissions which are linked to geothermal methods of electricity generation.

The European market for electricity

The EU electricity directive (96/92), which came into force in 1999[6] requires EU member countries to partially liberalise their electricity

markets. The directive required a liberalisation of at least 23 per cent of domestic electricity markets by 1999, at least 28 per cent by 2000 and at least 33 per cent by 2003 (Deutsche Bank Research 1998, p. 11). Member countries have to specify certain, usually large-scale, energy users that are permitted to negotiate the supply of electricity with independent domestic or foreign suppliers. The owners of the national electricity grids are required to allow the transmission of electricity by foreign or independent suppliers in return for a negotiable fee. As the degree of liberalisation increases, more and more energy consumers will be allowed to choose independent domestic or foreign electricity suppliers. Additionally, EU countries are no longer allowed to discriminate against investment in power generators and electricity networks by independent domestic or foreign EU firms (European Commission 2001a).

As cross-border access underlies reciprocity regulations and requires further administrative and technological harmonisation between EU member countries, the effective liberalisation of foreign trade in electricity is expected to lag behind the liberalisation of domestic energy markets of EU member countries. In 1999 the volume of cross-border electricity trading within the EU was equivalent to about 8 per cent of EU electricity generation (European Commission 2000c).

The objective of the electricity directive is to reduce energy prices for industry as well as for the service sector and private households while maintaining a 'satisfactory' level of supply security and avoiding conflicts with environmental policies (European Commission 1999a, p. 93).

In devising the directive, the European Union took account of the differences in the organisational structure of electricity markets across individual member countries. The United Kingdom, for instance, established competition in energy generation and distribution in the early 1990s. This gave customers the free national choice of their electricity supplier and allowed distribution companies to buy electricity in a competitive pool market.[7] The electricity sector in France, Italy, Portugal, Greece, Belgium, Ireland and Luxembourg is characterised by publicly-owned, vertically-integrated monopolies. In Germany, by contrast, a multitude of electricity companies were already in operation before the directive. However, as they had been legally granted regional monopolies, consumer choice was still restricted (Deutsche Bank Research 1998).

Sweden, Finland and the UK, which started liberalising their electricity markets in the early 1990s, have already achieved fully liberalised electricity markets. Denmark, Germany, the Netherlands and Spain are also aiming for a full liberalisation of their electricity markets, exceeding both the directive's proposed level of liberalisation and its time frame requirements. Deregulation in these countries is comparatively easy as they already had

oligopolistic market structures under the old regulatory regime. Countries with publicly-owned vertically-integrated gas companies, however, find the transition towards liberalisation more difficult to achieve and have opted for the minimum requirements the directive stipulates[8] (European Commission 1999a, p. 93).

Differences in the organisational structure of electricity markets are reflected in national variations of the level of concentration in the markets. Table 3.2 shows the differences in the levels of concentration in electricity generation markets in the EU.

Table 3.2 Market share in electricity generation in the EU, 1999

Country	Market share of largest electricity generator (in %)
Belgium	88.9
Denmark	26.0
Germany	28.1
Spain	44.7
Portugal	58.0
France	95.0
United Kingdom	15.0
Luxembourg	13.5
Sweden	53.0
Finland	26.0
Austria	51.7
Netherlands	32.6
Italy	71.0
Ireland	96.6
Greece	98.0

Source: Eurostat (2001a).

As a consequence of the liberalisation of electricity markets, prices for both the industrial sector and the domestic sector generally fell within the EU between 1998 and 2000 (European Commission 2001c). Falling electricity prices led to a rise in consumption, the precise increase depending on the price elasticity of demand for electricity. As competition intensifies and electricity prices fall, less efficient electricity producers are forced out of the market. In the case of the UK this led to a substitution of uncompetitive coal fired power stations, with high pollution levels, by more resource efficient gas powered generators characterised by lower pollution levels. In the short run at least, the improvement in pollution efficiency of energy generating firms appears to have outweighed the negative effects from increased use of electricity (Eikeland 1998, p. 920).

In the long run the effect of liberalisation on pollution levels seems less clear cut. While the projection of an environmentally friendly image can help the marketing of electricity companies, in the long run, prices are the most important factor influencing electricity consumption. For private electricity companies the capital costs of investment in alternative or renewable energy are higher than those for more traditional types of energy generation, due to the greater uncertainty about the profitability of these investments. Consequently they are more reluctant to invest in such technologies than publicly-owned companies (Eikeland 1998, p.924). In Sweden this problem has been tackled rather imaginatively by offering large energy consumers 'green contracts' for electricity produced in an environmentally friendly manner. Retail companies like McDonald's, as well as financial institutions which use life-style marketing as an important tool to attract customers, are prepared to pay a premium on their electricity prices in order to be able to advertise an environmentally friendly image. This also applies to firms which try to gain access to certified labels for environmental friendliness, like many furniture or paper companies (Eikeland 1998, p.925).

Research suggests that the anticipated reduction of energy prices is partly linked to the effect of increased national competition and partly to advantages from the intra EU trade of electricity (Amundsen and Tjotta 1997).

One major obstacle in the liberalisation of electricity markets is the reliance of these markets on network systems for the transport of electricity. As electricity is very difficult to store in large quantities and therefore needs to be produced just-in-time, the transmission network serves as a mechanism to co-ordinate the activities of a large number of both energy suppliers and energy users. The more energy suppliers and energy customers are linked through one network, the higher the utility of this access to each of them. The more suppliers, the larger the choice for consumers and the safer the supply. The more customers, the larger the potential customer base for each supplier. Consequently faults in the electricity grid which cut off suppliers or customers can lead to significant economic knock-on effects. Not only do the benefits for actual and potential users increase the more users are connected through a network, the marginal cost of attaching new customers or suppliers to an existing transmission network are usually also rather low. Consequently whoever owns the first transmission network has significant first-mover advantages in the market, which severely limit market entry. Electricity transmission networks are therefore usually regarded as natural monopolies. If left unchecked, the grid owner has the power to exploit all other participants in the electricity industry. Unless the operator is the sole user of the electricity grid, that is, is a vertically

integrated monopoly supplier, access to the grid needs to be regulated to enable competition in energy generation and distribution. In the UK for instance the company which owns the national electricity network is not allowed to invest in electric power generating or distribution companies (DTI 2000).[9]

The EU directive on electricity, like that on gas, does not demand the disintegration of existing electricity companies, it merely requires vertically integrated electricity companies to file separate accounts for the different parts of their business in order to achieve a greater transparency of the transmission costs (European Commission 2001a). These regulations in effect leave room for vertically integrated electricity companies to discriminate against competitors that need access in order to reach their suppliers or customers. Given the possibilities for creative accounting the grid owners are likely to be able to engage in cross subsidisation. They also might refuse to allow the competitor to feed electricity into the network during peak periods due to actual or fictional capacity shortages (Tennbakk 2000).

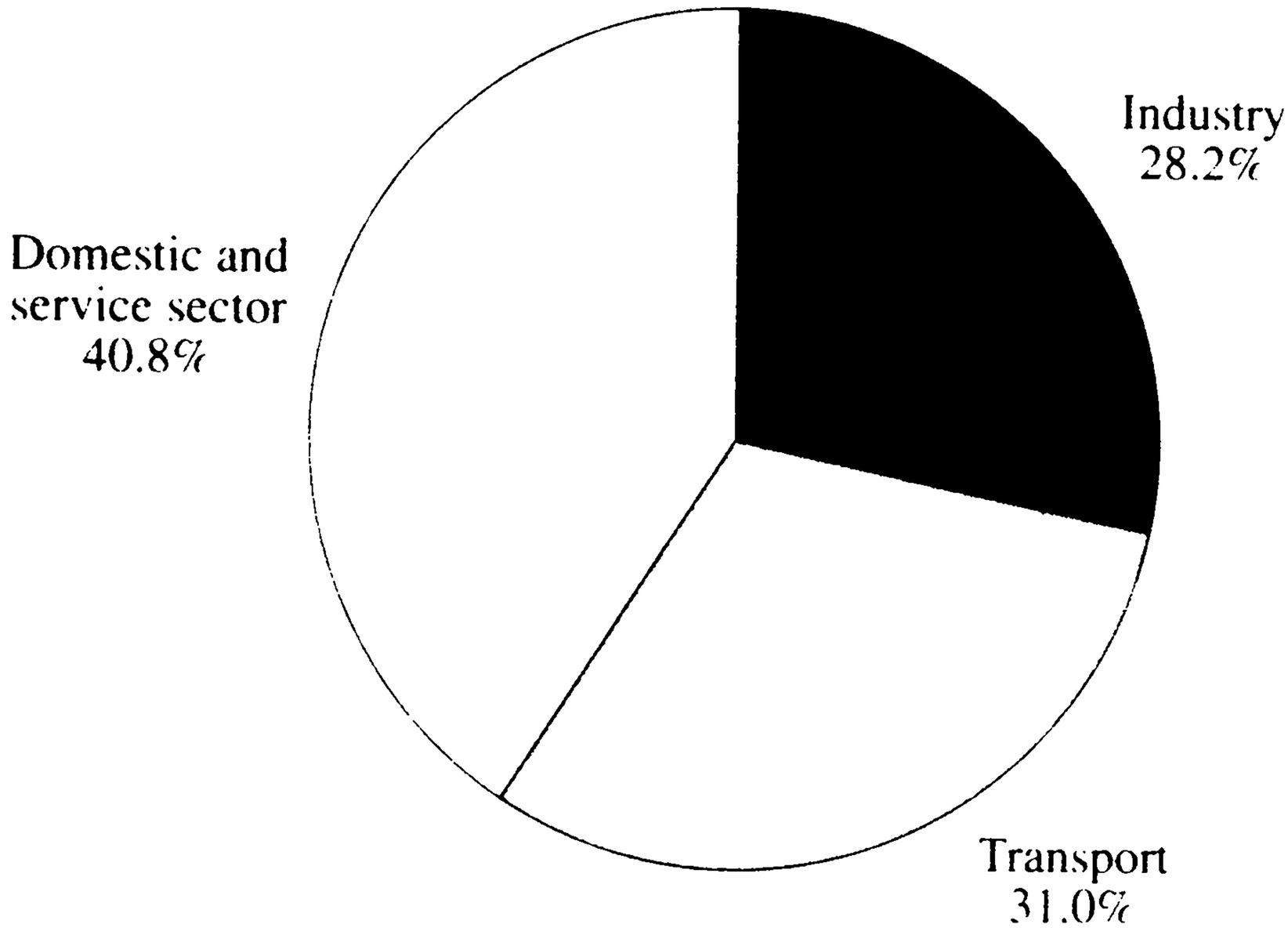
While the liberalisation of the electricity generating sector aims at increasing cost efficiency in the production of electricity, the liberalisation of distribution is supposed to ensure that cost reductions are translated into cheaper prices for consumers. As electricity generation and distribution markets move from monopoly to more or less wide oligopoly or contestable markets, economic rent is transferred from producers to consumers as prices fall and less efficient suppliers leave the market. As the economic rent gained by electricity consumers is larger than the producer rent lost by electricity generators and distributors, the economy as a whole experiences an additional social gain.

ENERGY DEMAND IN THE EU

From the demand side perspective the end-users of energy are customarily grouped under three headings: industry, (private and commercial) transport and the domestic and service sectors. Figure 3.5 shows that the domestic sector and service sector account for about 40 per cent of energy consumption, whereas industry and transport each account for about 30 per cent.

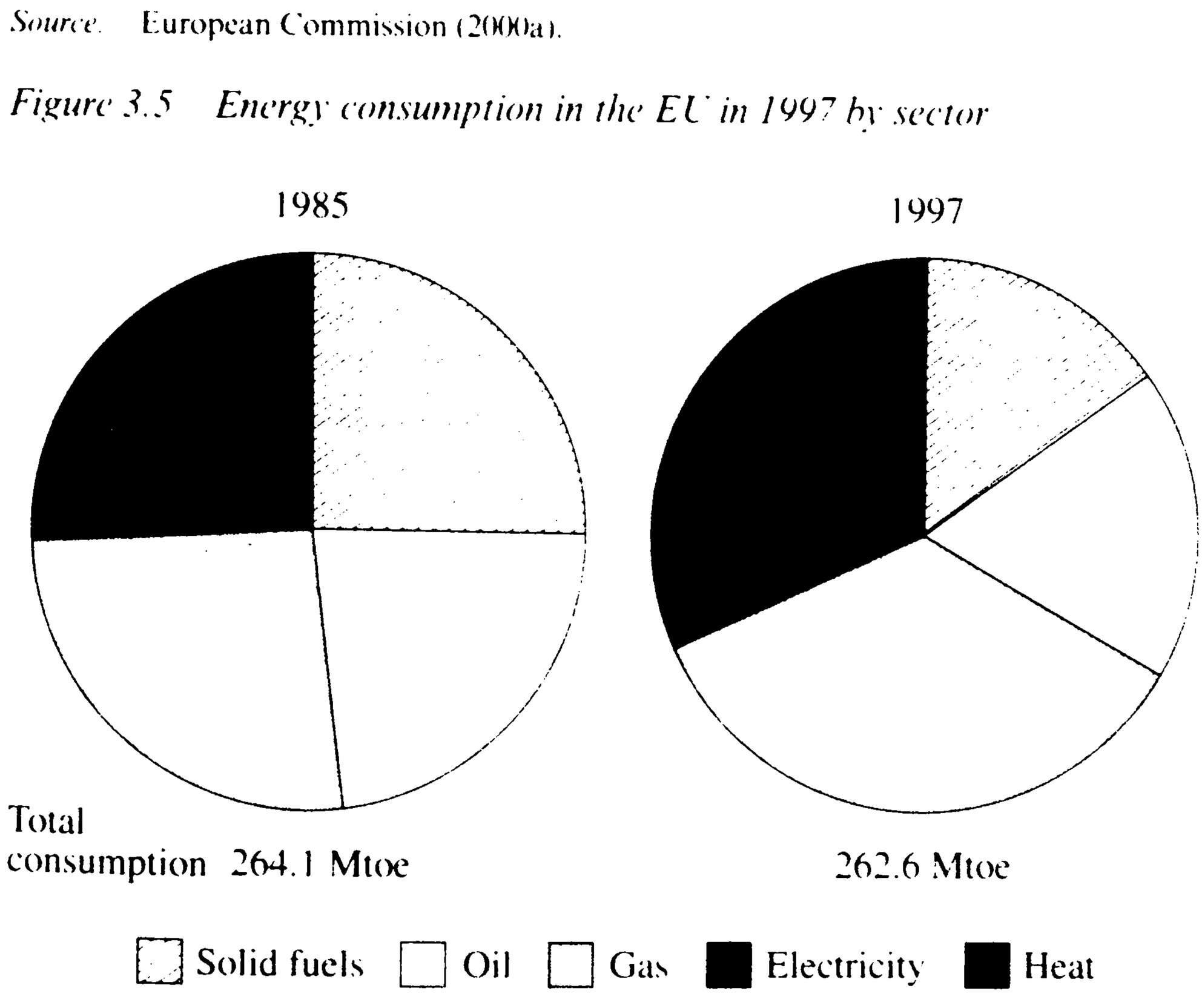
Industry

Industrial consumption of solid fuels and oil has been falling consistently since 1985 while demand for gas and electricity has been increasing (see Figure 3.6). These changes in the fuel mix are mainly due to the reduced



Source. European Commission (2000a).

Figure 3.5 Energy consumption in the EU in 1997 by sector



Source. European Commission (2000a, p. 44).

Figure 3.6 Changes in the fuel mix of energy consumption by industry

share of energy intensive sectors (for example, iron and steel) in EU industrial production, developments in gas technology which reduce the negative ecological impact of gas and the progressive liberalisation and subsequent price reductions in the European gas and electricity markets since the early 1990s (European Commission 2000a, p.43).

Since 1985, energy consumption per unit of industrial production in the European industry has fallen by 20 per cent (European Commission 2000a, p.42). Due to the reduction of the importance of energy-intensive industries for the European economies and technological developments which enable a better utilisation of energy the demand elasticity of energy with respect to GDP has fallen. This has been particularly true for countries such as Sweden, Finland, Denmark and Austria, which have shown a sustained increase in industrial production. The economic growth in these countries allowed a more efficient utilisation of available energy production capacities and the expansion of production capacities using new, more energy-efficient technologies.

Throughout the EU energy intensity levels vary considerably (see Table 3.3). This is partly due to differences in the economic development and industrial structure of the member countries and partly the result of varying national policies to induce the development and adoption of energy conserving technologies and patterns of behaviour.

Table 3.3 Specific industrial energy intensity IEI (1985 = 100) in 1997

	EU	Belgium	Germany	France	United Kingdom	Italy
IEI	80.2	93.2	63.2	83.8	90.4	91.9

Source: European Commission (2000a, p.45).

As Table 3.4 shows, prices for industrial energy also differ considerably between different member countries, a reflection of differences in access to primary resources, the absence of fully competitive energy markets within the EU and differences in the level of competition on domestic electricity and gas markets.

National differences in energy prices throughout the EU have led to variations in energy consumption patterns as industrial consumers try to choose those energy sources which are most cost-efficient for their purposes. They also affect the incentives to use energy more efficiently by investing in research in, and the introduction of, energy conserving production technologies.

It should be noted that energy prices in the United States are more than

Table 3.4 Energy prices to industrial consumers in 1990 euro[a] per toe[b] in 1997

	EU	Belgium	Germany	France	United Kingdom	Italy
Steam coal	73.2	n.a.	67.5	95.0	61.4	63.0
Heavy fuel oil	122.4	106.3	n.a.	98.4	106.3	143.3
Natural gas	118.9	94.6	133.0	111.9	68.2	158.4
Electricity	506.9	461.6	584.7	415.3	515.0	903.6

Notes:
[a] Excluding refundable VAT.
[b] toe = tonne of oil equivalent or 10^7 kilocalories or 41.86GJ.

Source: European Commission (2000a, p.46).

one-third lower than the European Union average. In Japan, however, energy prices are on average twice as high as in the EU (European Commission 2000a, p.68). These differences increasingly affect the global competitiveness of the European industries.

Transport

The transport sector is responsible for about 30 per cent of total energy consumption in the EU (see Figure 3.5).

Over the last twenty years the volume of passenger traffic in the EU has been growing steadily at about 2–3 per cent per year. Almost 80 per cent of passenger traffic is conducted by car. While car travel for work-related traffic has remained fairly constant, leisure-time travel has risen significantly. Air traffic also has become more popular, while rail and bus traffic have been decreasing and now jointly account for less than 15 per cent of passenger traffic. The increase in passenger traffic and the changes in the use of the different modes of transportation have led to a significant increase in the energy demand from passenger traffic over the last 20 years. Technological innovation is expected to lead to an increase in energy efficiency of aircraft, passenger cars and rail transport during the next twenty years. Consequently, the demand for energy for passenger transport is expected to increase more slowly than previously. The EU expects energy demand for passenger transport to increase by about 1.1 per cent per annum over the period from 1995 to 2020 (European Commission 1999b, p.130).

The introduction of just-in-time methods of production in the early

Table 3.5 Energy prices of transport fuels in 1990 euro[a] per toe in 1997

	EU	Belgium	Germany	France	United Kingdom	Italy
Premium unleaded gasoline	1037.5	1079.3	957.8	1063.4	1004.7	1282.1
Diesel	593.9	532.7	524.0	555.2	730.7	730.1

Note. [a] Excluding refundable VAT only for Diesel.

Source: European Commission (2000a, p. 50).

1990s has led to a significant increase in goods transport. The main beneficiaries of this development have been road, sea and, to a lesser extent, inland waterway transport. While sea and road transport now each capture about 40 per cent of the transport market, rail transport today provides less than 10 per cent.

As oil accounts for more than 98 per cent of the energy demand of the transport sector, fuel taxes have become the focus of energy policies aimed at reducing the consumption of energy and energy generation related pollution. Fuel taxes not only serve as instruments to generate income for the state but also act as incentives for a more efficient use of energy for transport purposes. Within the EU prices for transport fuel vary considerably both between individual countries and for different types of fuel (see Table 3.5). In April 1999 for instance fuel taxes accounted for between 61 and 82 per cent of the final diesel and unleaded gasoline prices. These differences in the level and structure of fuel taxes reflect variations in national economic and energy policies.

The Domestic and Tertiary Sectors

Energy consumption by the domestic sector is a function of population, number of households, private income and the weather. While year on year changes in the climate, for example particularly mild or cold winters, significantly affect energy consumption by private households, the long-term increase of energy use by domestic households is mainly influenced by rising living standards which are reflected in an increase in the size of flats and houses as well as by a wider use of electrical appliances such as computers, video recorders and modern cooking equipment.[10]

The service sector has a comparatively low energy intensity. In 1995 it accounted for 60 per cent of the value added of the EU but only for 13 per cent of final energy consumption (European Commission 1999b, p. 149).

The energy consumption of the service sector is a function of per capita income and the development of the knowledge economy. The demand for services related to leisure and telecommunications rises more than proportionately with income. Increasing office space to accommodate additional staff and the expansion of shopping outlets to attract additional trade fuelled by increasing per capita income lead to an increase in the demand for energy for heating and lighting. The increased use of computers and electronic audio-visual communication not only contributes to the growth of the service sector, but also leads to an increase of its energy intensity of production as new means of electronic data processing and electronic means of communication require more energy.

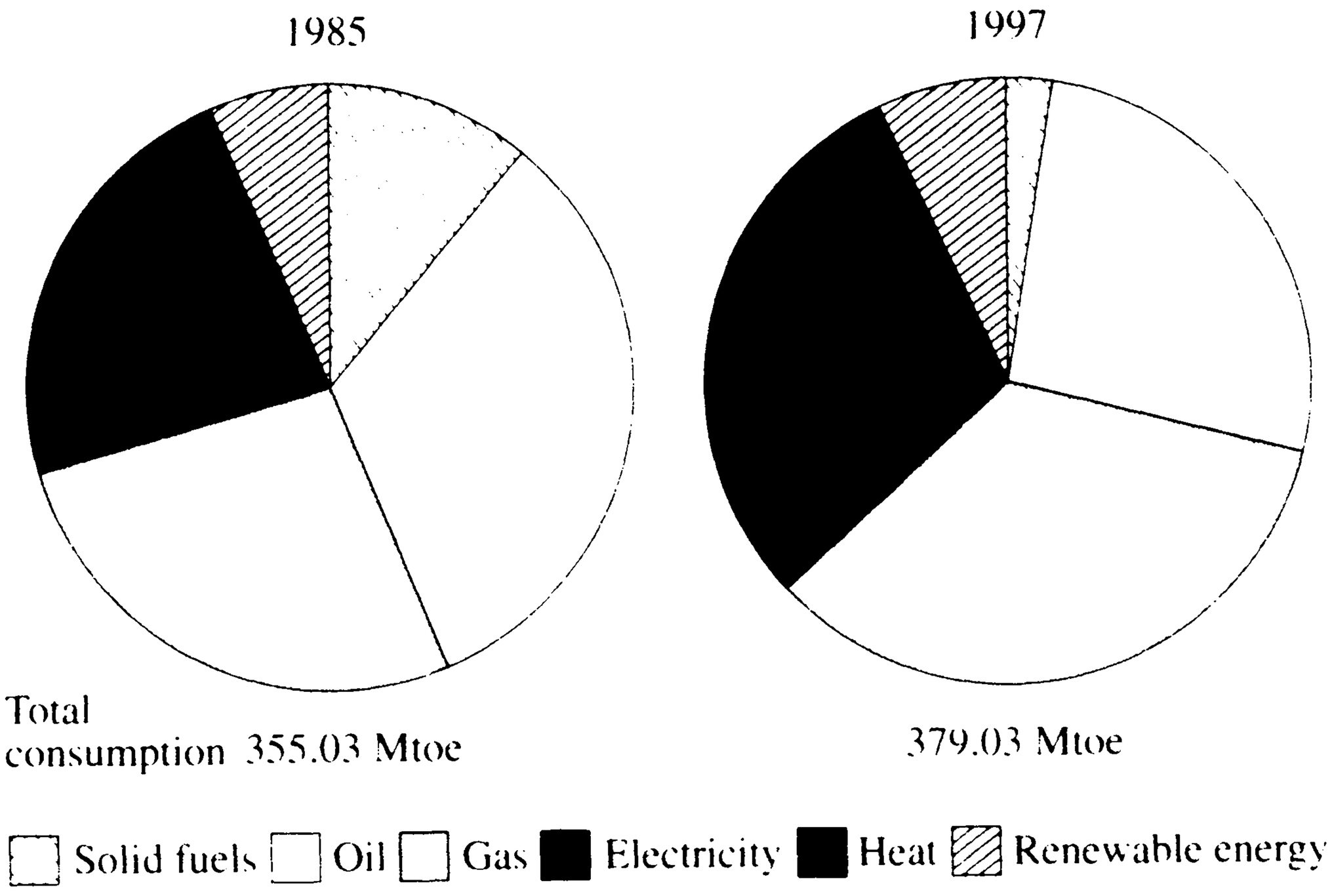
New building materials and construction guidelines have promoted the increase of energy efficiency of buildings and technological change has improved the energy efficiency of appliances. These developments have helped to moderate the increase in energy demand that would otherwise have occurred due to rising living standards and the growth of the service sector. This in turn has affected the demand elasticity of the domestic and service sector with regard to per capita income and output of the service sector.

During the last twenty years gas and electricity have continuously increased their share in the energy market of the domestic and service sector at the expense of the share of oil and, especially, solid fuels. The domestic and the service sector are the only parts of the energy market in which distributed heat and energy from alternative sources (like geothermal or solar heat and biomass) provide more than 10 per cent of the energy supply (see Figure 3.7).

As with energy prices for industrial consumers energy prices for the domestic and tertiary sector also vary significantly across the EU (see Table 3.6). Comparisons between Tables 3.4 and 3.6 show clearly that energy prices for private households tend to be significantly higher than the prices paid by industry.[11] One reason for this is that the individual private households lack market power and the opportunities to utilise economies of scale that are possessed by the (large) industrial firms. Other reasons are differences in tax treatment and market regulation of energy supplies for the industrial and the domestic sectors.

EU ENERGY POLICY

In the Amsterdam Treaty of 1997 the EU set itself the aim of achieving sustainable economic, environmental, social and geopolitical development. These goals led to the development of three core objectives for EU energy policy:



Source European Commission (2000a, p. 51).

Figure 3.7 Changes in the fuel mix of energy consumption by domestic and tertiary sector in the EU

Table 3.6 Energy prices to domestic consumers in 1990 euro[a] per toe in 1997

	EU	Belgium	Germany	France	United Kingdom	Italy
Steam coal	302.2	305.8	n.a.	436.3	253.2	n.a.
Heavy fuel	341.6	223.5	239.0	347.5	211.9	837.7
Natural gas	317.2	297.7	291.8	312.5	231.7	562.7
Electricity	1104.0	1403.7	1309.0	1141.6	996.2	1530.2

Note [a] Including all taxes.

Source European Commission (2000a, p. 53).

(a) to safeguard the security of supply in order to minimise the risks and the possible impact a disruption of energy supplies would have on economic development;
(b) to promote the development of competitive energy markets in order to reduce energy costs both for private households and for industry;
(c) to promote environmentally benign energy use (European Commission 1999a).

We now examine each of these objectives in turn.

Energy Security

When energy price hikes and oil shortages during the oil shocks of 1973/74 and 1979/80 led to global recession it became obvious just how much modern economies depend on energy. The EU consumes about 15 per cent of all energy produced worldwide. Half of this energy is imported from outside the EU. While some countries like Denmark, the Netherlands and the UK are able to balance energy production and energy consumption fairly well, most EU countries have significant energy deficits and need to import the majority of energy used (see Table 3.1). Given the political situation in many of the world's leading energy exporting countries, this imported supply is under considerable risk from disruption by war, civil unrest or a breakdown of political and economic relations between the importing and exporting countries.

Projections by the Directorate-General for Energy indicate that the capacity of the EU's own coal, gas and oil resources are going to be in progressive decline by 2020. Additionally, many of the EU's nuclear power stations will be scheduled for decommissioning, particularly after 2015. As some EU countries, like Germany, are reluctant to build new nuclear power stations, at least some of this energy capacity will need to be replaced by power stations using imported gas, petrol or coal. The dependence on imports of energy from outside the EU is therefore set to rise in the future (European Commission 1999a, p. 20).

In order to increase the long-term security of energy supply, the EU promotes the use of a more diverse range of energy sources, particularly those which are renewable and the development of import relationships with a wider number of countries. To facilitate the international trading in energy, the EU supports the development of infrastructure networks both within the EU and with third countries (European Commission 1997). Additionally it sets incentives for research into the development of alternative methods of energy generation as well as of more efficient production and use of energy.

The high concentration of oil exports from the Middle East makes oil imports particularly vulnerable to disruption due to political disturbances. Moreover, the strong concentration of the oil supply market raises the danger of exploitation due to market power and collusive action. In the 1970s OPEC demonstrated that large cartels in tight oligopoly markets can have a major influence on market prices. In the 1980s and 1990s, however, OPEC has found it increasingly difficult to ensure the adherence of its members to its decisions on production quotas (Spilimbergo 2001, p. 349). As countries in the Middle East become less cohesive both in respect of OPEC policies and political and economic developments, the risk from the concentration of market power in the international oil market is likely to fall over time.

The European gas market is currently dominated by exports from Russia. The two other main sources of gas imports are Norway and Algeria. While the supply from Russia and Algeria is under a similar political risk to that affecting the oil supply from the Middle East, imported gas supply seems less exposed to political risk as a wider variety of gas suppliers in different regions is available.[12] While in the short term disruptions to the supply with imported gas can be met by EU-wide emergency gas reserves, long-term disruptions would necessitate large-scale infrastructure investments which would require considerable construction time. In order to reduce the risks of hold-ups in the distribution system, the EU supports the construction of new gas pipelines which run through countries with a low perceived risk of natural or political disasters (European Commission 1997).

Because of the need to invest in a supply infrastructure of gas pipes which connects suppliers and customers, gas exporting countries will need to engage in significant infrastructure investments if they choose to switch customers. This acts as a disincentive for gas exporting countries to break off supply contracts and increases the market power of the importing economies.

Competitive Energy Markets

Low energy prices make an important contribution to the maintenance of the international competitiveness of energy-intensive EU industries. Directives to liberalise the EU electricity (96/92) and gas sectors (98/30) and to reduce subsidies for the European coal industry are aimed at reducing obstacles to efficient energy markets.

The traditionally high degree of regulation and monopolisation in European energy markets has for a long time been justified in terms of concerns about the safety of the national energy supply. As competition in

international product markets has increased, however, energy costs have become of increasing importance for the competitiveness of national industries in international markets. The aim of the privatisation and liberalisation of national energy markets since the early 1980s has been to introduce or intensify the competition between different energy sources and energy providers in order to promote increases in the efficiency of energy mining, generation and distribution as well as falling energy prices.

The directives for the liberalisation of electricity and gas markets at a European level aim at creating an EU-wide market for energy. This is no easy task as most national energy markets, particularly those which rely on infrastructure networks for their distribution systems like electricity and gas, still have an oligopolistic market structure.

In order to enable foreign competitors and new market entrants to compete efficiently, availability of and access to distribution networks like gas or oil pipelines or power grids needs to be ensured. The EU has acknowledged the importance of networks for the development of a Single European Market for energy by supporting the development of trans-European networks for electricity and gas (European Commission 1997).

The aim of competitive energy prices frequently conflicts with the aim of environmental protection through the promotion of a more environmentally benign use of energy. For example, reductions in the price of energy due to increased competition may weaken the incentive to invest in research into, and the implementation of, energy conserving technologies. On the other hand, taxes which aim to incorporate the social costs of pollution into the private costs of the energy users and regulations which require investment in more energy efficient generators and appliances will lead not only to a reduced use of energy but also to an increase in the costs of energy to industry.

Environmental Policies

The EU's main concern about pollution in the energy sector is CO_2 emissions caused by energy generation using fossil fuels. While the EU has managed to reduce absolute and per capita CO_2 emissions despite continued economic growth,[13] air pollution in the energy sector remains a top priority on the EU's environmental agenda. All EU member countries signed up to the 1998 Kyoto protocol on the reduction in carbon emissions. Under the terms of the protocol, the EU as a whole needs to reduce its CO_2 to 92 per cent of its 1990 pollution level by 2008–2012 (European Commission 2001d).[14] The two largest contributors to CO_2 emissions in the EU are electric power generation and transport, followed by the domestic and service sectors and industry. Apart from the transport sector,

where the increase in both commercial and leisure road transport has led to the continued increase in CO_2 emissions, all sectors have been able to reduce their pollution levels. Even in the transport sector the use of more energy efficient combustion engines and catalytic converters has ensured that pollution levels are lower than they otherwise would have been (European Commission 1999a).

Environmental policy has used two principal mechanisms to reduce pollution: taxation and regulation. We look at each in turn.

The wide variation in the structures and levels of energy taxes between member countries of the EU reflect not only national differences in public preferences for the protection of the environment but also questions about the effectiveness of the different policy measures which are used to promote more environmentally benign uses of energy (de Groot et al. 2001, p.718; Shrestha 2001; Damania 2000).

Environmental taxes aim to incorporate the marginal social costs of energy generation, distribution and use into the private costs of the energy users. As pollution tends to have long-term cumulative and often unpredictable effects on the environment, the social costs of pollution are hard to predict. The debate on the possible impact of CO_2 emissions on global warming is one example of this uncertainty. Not only is there a debate among scientists as whether or not CO_2 emissions are linked to global warming, but different countries and political groups value the risk that such a link exists differently. While for instance Bangladesh is particularly exposed to risks from global warming due to the likelihood of flooding, countries like Austria and Switzerland appear to be comparatively immune from this particular threat. While on average more highly developed economies tend to be able to spend more on environmental protection, they are often also more dependent on energy. The decision of the US American Bush administration in 2001 to distance itself from the Kyoto protocol is an example of a highly industrialised nation setting actual economic interests before potential ecological concerns.

While environmental taxes are largely under the authority of individual EU Member States, the EU has nevertheless issued directives on regulations on such matters as maximum vehicle and heating system emissions, new environmental specifications of petrol and diesel fuels and tighter guidelines on the insulation of buildings (European Commission 2001b).

As the social costs of energy pollution are not limited to individual nation states, the EU has also tried to influence the energy policy of other countries in favour of more environmentally benign methods of energy generation and use. The incentives the EU provides range from subsidies to preferential trade agreements.

The tension between the EU's aim to promote the development of com-

petitive energy markets and to support the environmentally benign use of energy is particularly obvious in the case of the EU electricity directive (96/92). While the introduction of the directive has successfully led to a decrease in the price of electricity for the majority of commercial and private electricity consumers in the EU, the directive casts significant doubts on the legality of member countries' attempts to subsidise the use of renewable energy. In the light of the demands of the Kyoto agreement on the EU, the promotion of the increased use of renewable sources of energy is welcomed both by the European Commission and EU member countries. However, in a report published in 1998 the European Commission acknowledged that the electricity directive (96/92) failed to make provisions to ensure that subsidies for the use of renewable energy in large scale electricity generation could be provided legally by member countries (European Commission 1998). While not outright denying member countries the right to support the use of renewable energy, the European Commission failed to give clear guidelines on what type of policies would be considered legal and what would be illegal.

CONCLUSION

This chapter shows that the EU energy industry is faced with numerous challenges. The degree to which these challenges are met will influence significantly the future wealth and well-being of the EU population. The energy political objectives of the EU, to safeguard energy supply, to promote the environmentally benign use of energy and to develop competitive and cost-efficient energy markets all have significant merits in their own rights. As has been shown, however, the methods by which each of the three objectives are being promoted frequently negatively affect one or both of the other objectives.

Both with respect to energy security and environmental policy the EU energy industry operates directly within a global context. Solutions to these problems can only be found in close co-operation with other countries. As the disputes about the Kyoto agreement demonstrates, such co-operation is difficult to achieve.

The deregulation of EU energy markets both on national and EU level has led to a significant decrease of energy prices in the last twenty years. However, the need to rely on infrastructure networks in the gas and electricity sector and the oligopolistic nature of most sectors in the energy market require continuous market regulation both on national and EU level in order to avoid discrimination against new market entrants and the exploitation of energy consumers (see European Commission 2001e).

NOTES

1. The long-distance transport of gas or electricity by contrast requires large-scale investment in distribution infrastructure in the form of electricity grids and gas pipelines.
2. Only about one-tenth of the gas supply is sold in liquid form and distributed via ship, rail or road transport.
3. The gas directive required member countries to liberalise at least 20 per cent of domestic gas markets by 2000, at least 28 per cent by 2003 and at least 33 per cent by 2008 (Deutsche Bank Research 1998, p. 14).
4. The members of the OPEC are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudia Arabia, The United Arab Emirates and Venezuela. Together they produce about 40 per cent of the world's oil and hold more than three-quarters of the world's proven oil reserves. Since the Iraq/Kuwait war Iraq's membership of OPEC has been suspended due to sanctions by the United Nations.
5. For a good overview of the literature concerning OPEC output policies in the 1970s see Ramcharran (2001).
6. Due to concessions Belgium and Ireland were only required to enact the directive in 2001 and Greece in 2002.
7. The original electricity pool, which mainly acted as a price setting mechanism, was replaced in 2001 by new electricity trading arrangements (NETA) which allow near real time trading and enable electricity generating and distribution companies to arrange bilateral contracts.
8. Despite its oligopolistic market structure in the energy sector, Austria opted for a gradual approach as well.
9. In the UK this applies to all privatised network industries, that is, electricity, gas and the railways. Similarly, the electric grid which is jointly used by Norway, Sweden and Finland is also owned by three separate (national), independent companies (Tennbakk 2000, p. 863).
10. Research carried out in Norway suggests that the demand of private households for electricity is very price inelastic both in the short and in the long run (Halvorsen and Larsen 2001).
11. It should be noted that prices in Table 3.5 do not include VAT while those in Table 3.6 do. The reason for this is that indirect taxes on consumption, like value added taxes, are collected through the producing firms but should be carried by the consumer. This applies both for industry and the service sector.
12. Economic and infrastructure links for gas supply are being developed with Egypt, Nigeria, Trinidad and the Middle East.
13. Liaskas et al. (2000) provide a detailed analysis of the relationship between economic growth and carbon dioxide pollution in EU countries.
14. The Kyoto agreement proposes the reduction of the emission of six so-called greenhouse gases including CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. As the gases have different global warming potentials, reduction targets are set in CO_2 equivalents (Eurostat 2001b). The overall reduction is to be achieved by setting different emission targets for different member countries, based on their economic development (Energy Information Administration 2000).

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